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Solid Earth Discussions

Interactive comment on "Earth's surface heat flux" *by* J. H. Davies and D. R. Davies

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This paper uses a compilation of heat flow data and the recent geological map of the world in digital form to obtain a new estimate of the present energy budget of the solid Earth. This estimate is higher than, but not significantly different from the results of previous studies. Actually it is 10% higher than the estimate of 43 TW by Williams and Von Herzen (1974), more than 30 years ago.

While the final value is not very different from those obtained by previous studies, there are important differences in the methodology used, which I think are worth discussing. The paper takes advantage of the most recent compilation of the world surface geology. The study illustrates the advantages and the pitfalls of using global compilations. The main difference between the approach of this paper and the one that we (Jaupart et al., 2007) have used concerns the continental heat flow. In our study, we have used com-

pletely different method for the continental and oceanic domains. In the oceans, we all use age as a proxy for heat flux. The reason we can do so is that the relationship between heat flux and sea floor age is based on a physical model the plate cooling model, which for young ages is identical to the half space cooling model. The parameters of this model depend on physical properties of rocks and on mantle temperature, and can be tested against heat flux measurements, when they are not affected by hydrothermal circulation. The cooling plate model is supported by the variations in bathymetry and geoid with age, and more recently by shear wave velocity cross sections based on surface wave seismic tomography. There is no such simple relationship based on a physical model in the continents. The suggestion of a relationship between heat flux and age of the continental crust dates back to Polyak and Smirnov (1968). It is based only on very weak statistical trends. There is an anti-correlation of heat flux with age for young crust that is in transient thermal regime. But the trend is weak at best for the Paleozoic and older ages (Morgan, 1985). The suggestion that age could be a proxy for heat flux in the continents has thus been challenged by many authors (Morgan, 1985, Jaupart and Mareschal, 2007). The main component of the surface heat flux in continents is crustal heat production. Although there is some decrease in heat production with age, the range of province wide averaged heat production within each age group is much wider than the differences between age groups (Jaupart and Mareschal, 2003, and references therein). That is why we believe that, with the present sampling of continental heat flux it is preferable to estimate the mean continental heat flux by area weighted averaging. It turns out that binning the data by age or area weighting them yield estimates that are not very different, probably a reflection that the sampling is adequate. The important point though is that one cannot use age to predict heat flux in poorly sampled regions.

I am not sure that I understand some of the final arguments on the global budget. The authors state that higher surface heat flux implies a hotter mantle and therefore requires less cooling from the core. This seems in contradiction with the statement in the previous paragraph that mantle cooling was probably less than 200K during the

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past 2.5 Gy (and not from the initial condition). If the bulk silicate Earth model is valid, then higher surface heat loss can only be balanced by higher core cooling, regardless of the present mantle temperature.

The paper is easy to follow, except for the annoyance of the too many acronyms. I also think that some statements are a bit confusing. The calculation of the oceanic heat loss based on a cooling model is not a correction. I think the tables need to separate clearly the oceanic and continental regions with separate totals, including for the surface areas. One has to struggle to extract the information from the tables. Figures 3 to 8 illustrate minor technical points. They are not very useful.

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Morgan, P, 1985. J. Geophys. Res., 90, 561 Polyak, B.G., and Smirnov Y.A., 1968, Geotectonics, 4, 205. Williams, D.L., and von Herzen, R.P. 1974. Geology, 2, 327.

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